Live Fire Development Testing and Modeling & Simulation

A Balanced Approach

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Title Page

This presentation provides a discussion of both Live Fire and Predictive Simulation associated with Development Testing. This discussion suggests that a balanced approach is better suited in today's spiral development environment where rapid improvements can be fielded without the resources to conduct at sea testing for all changes.

This presentation is primarily focused on Development Testing and may have some relevance to post development/fleet in-service live fire testing. This presentation also is more focused on short range ship defense development testing.

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ive Fire At Sea Development Testing History

- **USS MISSISSIPPI – Project Bumble Bee (1950s)**
  - Led to Talos, Terrier, Tartar
- **USS NORTON SOUND – Aegis, MK 26 and MK 41 L**
  Systems (1960s-1970s)
- **Ex-USS STODDARD – Close In Weapon System (198**
- **Ex-USS DECATUR – Self Defense Systems (1990s)**
- **Ex-USS PAUL F. FOSTER – Self Defense Systems (2**

Dedicated Fleet Assets to Prove to Sailors Systems Work At Sea

Live Fire Missile development testing has a history that came from the sophistication of air power during WWII which demanded development of modern, effective anti-air warfare weapons.

Project Bumblebee, a radar beam riding projectile, was developed and tested on USS MISSISSIPPI (CGN 40). From this effort, industry and the Navy made improvements that led to the surface Navy 3T missile efforts - Talos, Terrier and Tartar. Live Fire Testing was completed for these missile, on guided missile cruisers, missile guided destroyers and frigates.

The U. S. Navy needed a dedicated ship to perform development testing for new Combat and Weapon Systems. In the 1960s-1970s, the USS NORTON SOUND (AVM 1) was utilized out of Port Hueneme, California for the development test of the Aegis Combat System and the associated MK 26 and MK 41 launchers.

The Navy also needed to look closely at ship self defense. The Anti-Ship Cruise Missile was now in foreign Navy inventories and Ship Self Defense Weapons were to be developed. The challenge was how to test them realistically without putting a ship and sailors at risk.

From the 1980s through the present time, the U. S. Navy made decisions to dedicate a test ship for these purposes. STODDARD was a towed ship for Close-In-Weapon System (20mm PHALANX) and subsequently, the DECATUR (ex DDG-31) and PAUL F. FOSTER (ex

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Live Fire Development Testing Issue

- **Reduction in total number of Ships**
- **Increased OP TEMPO, Fleet Surge**
- **Insufficient dedicated periods of time for install a**
- **Focus on quality of life issues with shipboard pers**
- **Tightly Controlled Test environment**

Use of Navy Ships to support T&E must be kept to a minimum

Getting a test asset for Live Fire Testing was not easy.

The total number of ships was greatly reduced. Couple this with increased operational tempo (OP Tempo) and the current requirement to have surge ships ready for immediate deployment, it was difficult to get a commissioned operational ship that could meet the demands of a Development Test Program.

Often times, dedicated periods on operational ships to install Development Test Articles were insufficient, and when a ship was available, other factors such as long work weeks, weekends and a tightly controlled test environment effected quality of life issues for shipboard personnel.

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What's The Problem?

- **Fewer Ships**

  - - - but Live Fire Development Testing is critic

- **Solution is to have a balanced approach to Shipbo**
  Testing and M&S

So, what's the problem. Public Law Title X and OSD T&E Oversight require the Navy to conduct rigorous development testing including live fire. With fewer ships, the strictly controlled environment and parameters of testing and the schedule difficulties, it was a challenge to perform live fire testing in a smaller ship population, even with a dedicated test ship.

Alternatives were needed. A supplemental method to live fire was to use predictive simulations. The use of both predictive simulations and live fire testing now provided a balanced approach to meet development test requirements. Neither one method or the other should be an exclusive test method. The value of each needs to be assessed and prudent decisions made.

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Value of At Sea Live Fire

- **Reality of Environmental Conditions**
- **Realistic targets/threats and target profiles**
- **Problems uncovered that could not be learned else**

<u>Leads To:</u>

- **Confidence to the Fleet**
- **End to End System Testing with fleet operators**
- **Develops/Validates Operational Procedures**

Yes, but isn't this costly as exclusive Test Method?

The value of at-sea live fire development testing is crucial to demonstrate the effectiveness and safety of weapon systems.

The only place to do this is at-sea on ships with sailors as operators. This is the reality of the operating environment: ship motion, weather and people. The use of actual threats or threat targets and the target profiles are crucial to the test process. It is through this process of live fire testing at-sea on ships with sailors and real threats and threat profiles that a test of the development article is evaluated. And it has been proven that this live fire process at sea on ships with sailors and real threats and development profiles has uncovered problems that could not be learned elsewhere. Lab testing, Land Based testing, or simulations could not have picked these up.

In the end, the objective is to demonstrate the confidence to the end user-fleet sailors on ships. And through the use of fleet sailors on ships, the full detect through engage, end-to-end system test can be demonstrated and used to develop and validate the operational procedures for fleet development.

And the question then becomes, sure, great idea and a sound test philosophy, but this is a costly method of exclusive testing.

At sea test programs are not inexpensive. The cost for the developer, the test, the test ship, the test missile, test range and test target is high. For a single missile event, the cost could be in excess of $1M.

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Value of Modeling/Simulation

- **High Volume Data Samples**
- **Repeatability**
- **Availability of “Real Threat” Scenario**
- **Controllable Parameters not achievable or practica**

But this is not an exclusive method either

Predictive models and simulation have an advantage over the single event live fire in that high volume data samples can be run providing the statistical significance required for an engineering evaluation. And of course, repeatability is an asset over a single event methodology.

Even though live fire can provide the actual threat vehicle or the target replicating the threat, not all threats are available. With all parameters known, the real threat characteristics and profile can be accurately used in the computer simulation. Often times the threat profile parameters are not achievable or practical on a test range, and the computer simulation can be more relevant for engineering analyses.

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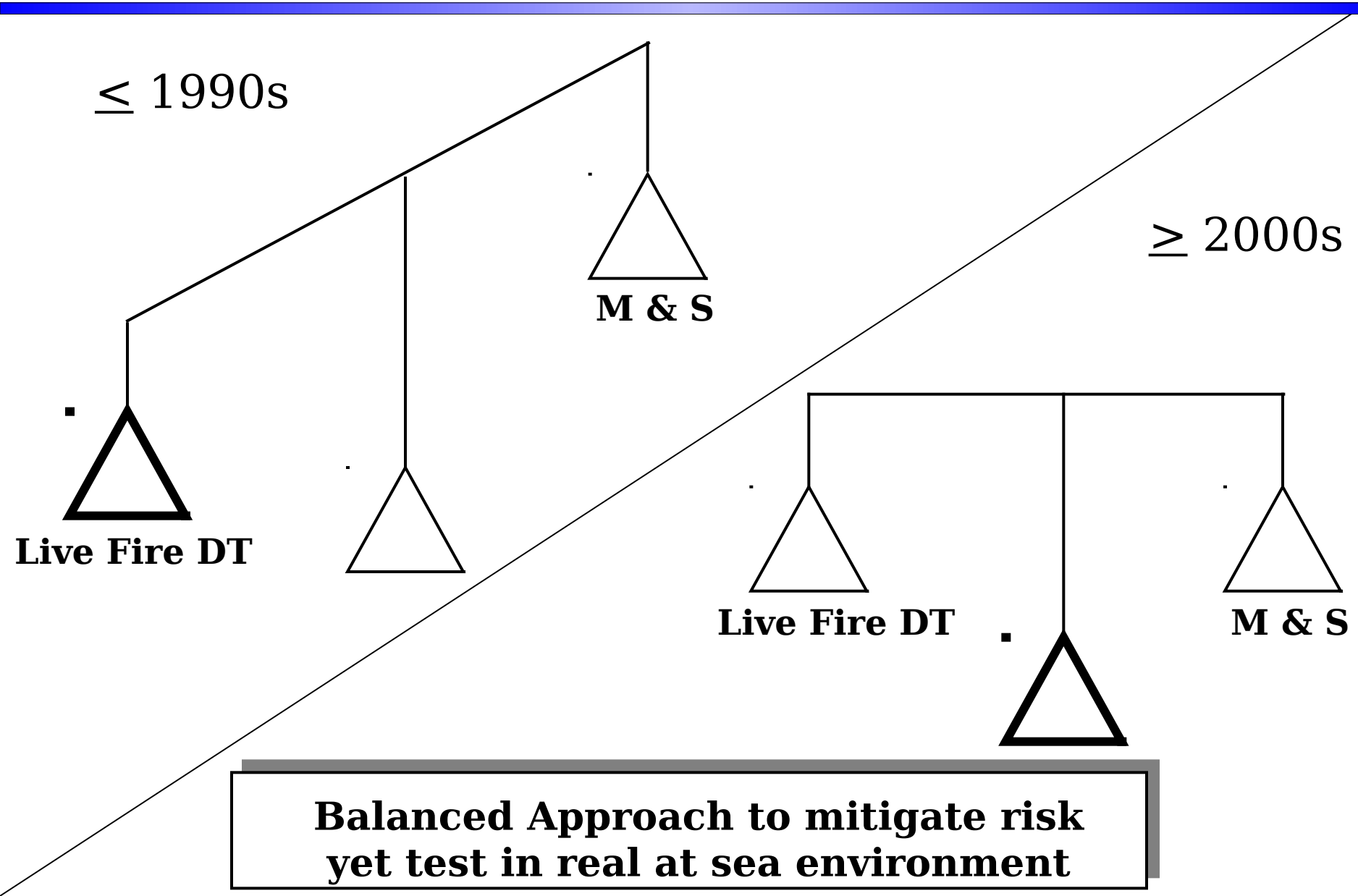
Solution: A Balance



Balanced Approach to mitigate risk yet test in real at sea environment

I believe an acceptable answer to the dilemma is the use of both Live Fire and Predictive Simulations.

As noted in this pictorial, prior to the 1990s, there was a very strong emphasis and implementation of live fire, with a minimal use of predictive model and simulations, nearly to an exclusive method.

I see the usage of a balanced approach of both test methods to be more appropriate in future development test programs. This is still not to say that one replaces the other. The usage of both methods is appropriate when evaluating risk, assisting with decision making in the face of

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What's in it for you?

- Program Managers need to have various test meth
  mitigate program risk and deliver systems that wo
- Program Managers suggest a 10:1 ROI for finding
  during development testing vs in production
- Systems are better able to perform mission
  - Reality Based Testing
  - Validated Models and Simulations

Well Tested Systems
Save Sailors Lives

As a program manager, technical director or test director one needs to have a variety of test methods built into a test program. These are needed to evaluate and mitigate technical program risk and to deliver systems that work at sea, on ships, operated by sailors.

As mentioned in an earlier slide, problems uncovered during development testing are usually found through the live fire test method. When found, they can then be plugged into the simulation for use in validating and improving the predictive simulation test method. Both methods, when used in development testing, can and have found problems early in the development phase. This has been suggested to provide a 10:1 return on investment by finding the problem now rather than after/during production. Spend a $1M now, can save a program up to $10M later in the life cycle.

With a balanced approach of reality based testing using live fire methods, supplemented with validate models and simulation, systems can be delivered that work.

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evelopment Testing has to be Realistic

- Get as close to real world scenarios
- Identify system problems before Fleet Installations
  Fire Development Testing and Modeling Simulatio
- Dedicated Test Ship is in the Navy Inventory

Maintain our Navy's Claim to having the best protected ships in the world

Development testing must be realistic. Realistic testing comes from Live Fire Test balanced with the use of predictive simulations.

Problems can be identified early in development and save the program and customer funding in the life cycle.

The U. S. Navy has dedicated a test ship, USS PAUL F. FOSTER, for the at sea demonstration of short range weapon systems and other surface combat and weapon system projects.

PAUL F. FOSTER and other dedicated test ships before, have successfully demonstrated the live fire capability for systems field on surface ships and were used to maintain the Navy's claim to having the best protected ships in the world.

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BACKUP

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blems Found with Recent Live Fire Test
hat were not/could not have been found with M&S

- **Missile InfraRed Flare Reject Discrimination (RAM)**
- **Missile Tail Fin (ESSM)**
- **Missile Flight Vibration – Component Shorting (RAM)**
- **Gun/WDS Interoperability (CIWS/SSDS)**
- **ESM/WDS Interoperability (SLQ-32/SSDS)**
- **Missile Software (RAM)**
- **Radar/WDS Interoperability (SPS-49/SSDS)**
- **ESM Threat Library Target Identification (SLQ-32)**

Discovered major Software Problem
Solutions Developed and Implemented prior to production

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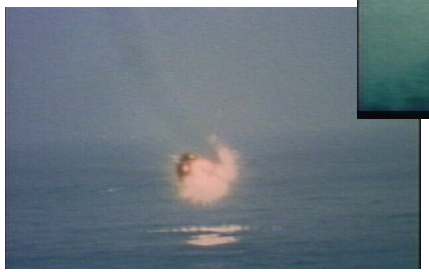
PAUL F. FOSTER (DD 964)
Self Defense Test Ship - Replacement

What Have We Done?

Target/Scenario Examples

- BQM-74E
- EXOCET MM-38
- VANDAL Stream
- VANDAL Maneuvering
- BQM-34S
- HARPOON Stream
- VANDAL Diver
- SETT



Systems Tested

- RAM Block 0 & 1
- CIWS Block 1A & B
- SSDS Mk1
- ESSM/Rearch. NATO
- TISS; IRSS
- RIM-7P/7P++

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Location is Everything

- Homeport
  - Port Hueneme Wharf
- Advantages
  - Deep water
  - Open Range
  - Littoral Environment
  - Proximity to Point Mugu
    - Navy's major test range
    - Realistic targets
    - Instrumentation
    - Ordnance loading
    - Remote control infrastructure